

Lower Urinary Tract Injuries Following Blunt Trauma: A Review of Contemporary Management

Jennifer P.L. Kong, MB, Bch,¹ Matthew F. Bultitude, MSc, FRCS,¹
Peter Royce, MBBS, FRACS, FACS,¹ Russell L. Gruen, MBBS, PhD, FRACS,²
Alex Cato, AM, RFD, FRCSEd, FRACS,¹ Niall M. Corcoran, PhD, AFRCSI³

¹Department of Urology, The Alfred Hospital, Monash University, Melbourne, Victoria, Australia; ²National Trauma Research Institute & Trauma Service, The Alfred Hospital, Monash University, Melbourne, Victoria, Australia; ³Department of Surgery, Royal Melbourne Hospital, University of Melbourne, Victoria, Australia

Lower urinary tract trauma, although relatively uncommon in blunt trauma, can lead to significant morbidity when diagnosed late or left untreated; urologists may only encounter a handful of these injuries in their career. This article reviews the literature and reports on the management of these injuries, highlighting the issues facing clinicians in this subspecialty. Also presented is a structured review detailing the mechanisms, classification, diagnosis, management, and complications of blunt trauma to the bladder and urethra. The prognosis for bladder rupture is excellent when treated. Significant intraperitoneal rupture or involvement of the bladder neck mandates surgical repair, whereas smaller extraperitoneal lacerations may be managed with catheterization alone. With the push for management of trauma patients in larger centers, urologists in these hospitals are seeing increasing numbers of lower urinary tract injuries. Prospective analysis may be achieved in these centers to address the current lack of Level 1 evidence.
[Rev Urol. 2011;13(3):119-130 doi: 10.3909/riu0521]

© 2011 MedReviews®, LLC

Key words: Multiple trauma • Rupture • Urethra • Urinary bladder • Wounds, nonpenetrating

Injury to the lower urinary tract is relatively uncommon in the setting of blunt trauma. However, it is particularly susceptible to those forces that produce sufficient energy to cause pelvic ring disruption. As a result, at least 85% of bladder ruptures are associated with pelvic fracture.^{1,2} Urethral disruption has been reported in 3.5% to 28.8% of patients with pelvic fractures, almost exclusively in men. In Victoria, lower urinary tract injuries occurred in 1.5% of major trauma patients in 2009 (data from the Victorian State Trauma Outcomes Registry). It is well recognized that prompt recognition and early management of

these urological injuries can significantly reduce morbidity and mortality. Difficulties arise in the severely injured multitrauma patient when life-saving measures or damage-control surgery may delay the diagnosis and treatment of lower urinary tract injuries. As management strategies have become more conservative, particular attention has been given to defining patients who would benefit most from intervention. This article describes the management of lower urinary tract injuries as practiced at Australia's busiest trauma center.

Bladder

The bladder is a muscular organ which, when empty, lies protected by the anterior bony pelvis. It is located extraperitoneally in the adult with peritoneum covering the superior surface. The dome is the most mobile and weakest part of the bladder, leaving it susceptible to rupture when the bladder is full. Associated injuries in bladder trauma are common and include pelvic fractures (93%-97%), long bone injuries (50%-53%), and central nervous system (28%-31%) and thoracic injuries (28%-31%).^{3,4} The mortality related to bladder trauma can be as high as 34% and is largely a consequence of associated injuries rather than bladder perforation itself.

Mechanism

Bladder perforation is seen most commonly in blunt trauma and infrequently as a result of penetrating injuries. Several mechanisms of bladder damage associated with pelvic fracture have been described: (1) bony fragments lacerating the extraperitoneal surface; (2) avulsion due to severe displacement forces when the rigid pelvis is fractured and ligamentous attachments are disrupted; and (3) direct force causing a "burst" injury to a full bladder that classically causes a large horizontal

laceration at the dome. It has been suggested that a fourth mechanism exists wherein pelvic fractures in association with extraperitoneal (EP) bladder rupture are coincidental rather than causative. In one series, only 35% of bladder perforations

the injury proximally from a urethral tear or distally from the EP bladder. The involvement of the bladder neck or ureteric orifices converts a simple bladder perforation into one that is complex and requires surgical exploration and repair.

The involvement of the bladder neck or ureteric orifices converts a simple bladder perforation into one that is complex and requires surgical exploration and repair.

were noted to have their injuries on the same side as the pelvic fracture.⁵ A proposed mechanism is that severe lower abdominal trauma causes an injury similar to that seen in a full bladder where the collapsed bladder ruptures from sheer blunt force.⁶

Complicated bladder lacerations involve the bladder neck and frequently there is disruption of the pelvic floor. This can result in contrast extravasation to the perineum, scrotum, penis, and anterior abdominal wall (Figure 1). Involvement of the bladder neck is often an extension of an injury. In adults, the laceration is usually a longitudinal split and can be caused by progression of

Classification

Bladder trauma can be broadly classified as contusions of the bladder wall or intramural hematomas that are self-limiting and require no specific treatment (Figure 2), EP injuries that occur in 60% of all bladder traumas (Figure 3), intraperitoneal (IP) lacerations that can be seen approximately 25% of the time in patients without pelvic fracture (Figure 4), and combined IP and EP perforations that occur in 2% to 20% of all injuries.¹ Bladder contusion is probably the most common type and is a relatively minor injury that does not require specific treatment. Radiologic findings are almost always normal in

Figure 1. Complex bladder neck injury with contrast extravasation into perineum on retrograde urethrogram.

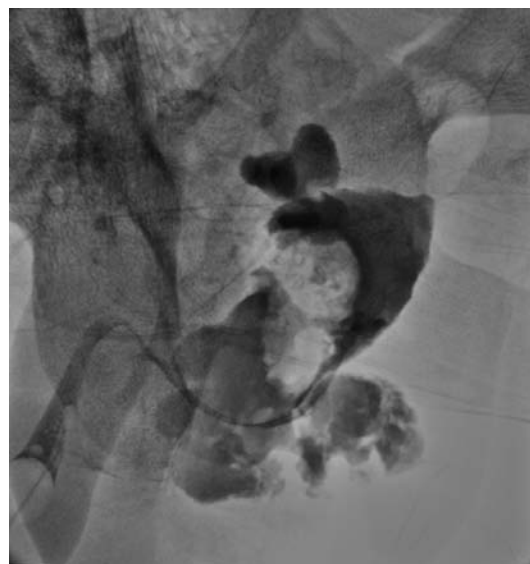




Figure 2. Computed tomography image revealing mural irregularity and clot at the dome of the bladder.

these patients with gross hematuria. Two classification systems exist, one based on radiographic appearance (Table 1)⁷ and the other on injury severity (Table 2).⁸ Although these classifications may be useful for research purposes, they are of little use clinically and are rarely used in day-to-day practice. In terms of clinical relevance, classification centers on differentiating between EP and IP injury and between simple and complex injury as treatment and

outcome may be different. These classifications are based on a combination of radiologic studies and/or findings at laparotomy.

Diagnosis

Gross hematuria is the most common sign associated with bladder rupture. It has been reported in 100% of all bladder injuries and its presence in conjunction with pelvic trauma is a well-documented predictor of injury. Other signs and symptoms include

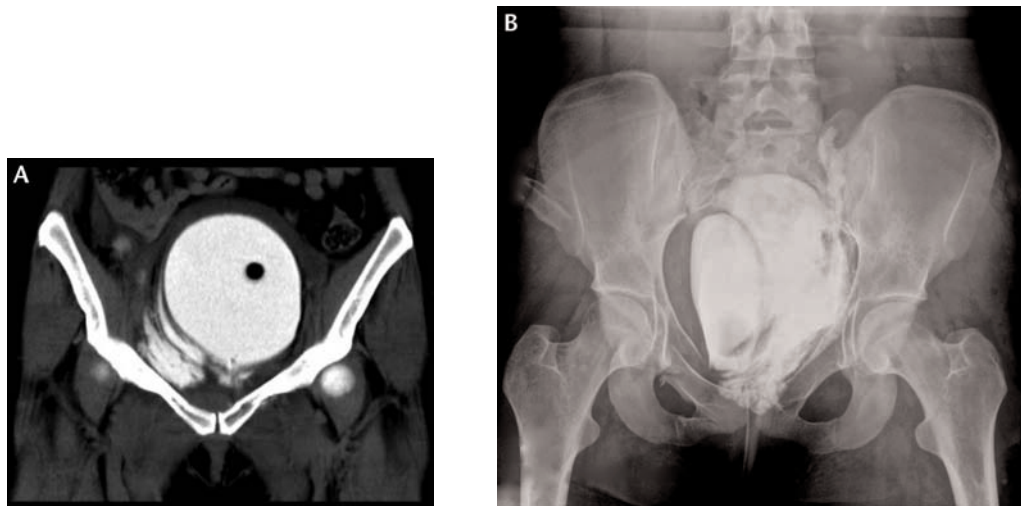


Figure 3. (A) Extraperitoneal (EP) contrast extravasation on computed tomography cystogram. (B) EP injury with contrast tracking giving the appearance of intraperitoneal contrast extravasation.

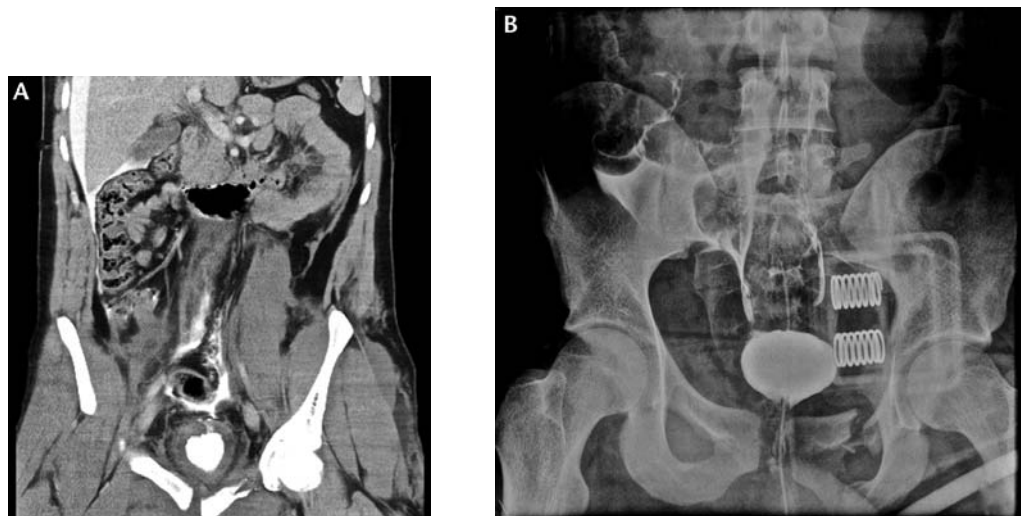


Figure 4. (A) Intraperitoneal (IP) contrast on computed tomography image of the abdomen. (B) IP contrast detected on retrograde cystogram.

Table 1
Radiologic Classification System⁷

Type	Injury	Radiographic Appearance
1	Bladder contusion	Normal
2	Intraperitoneal (IP) rupture	Ill-defined contrast extravasation surrounding loops of bowel and in the paracolic gutters and pouch of Douglas
3	Interstitial bladder injury (rare)	Contrast dissects into bladder wall, causing irregularity or defect; no contrast extravasation
4	Extraperitoneal (EP) rupture	
4a	Simple	Contrast is limited to the perivesical space with linear streaks or a sunburst pattern
4b	Complex	The pelvic floor is breeched and contrast may track up the retroperitoneal space and appear as an IP rupture; extravasation may extend to scrotum, penis, and anterior abdominal wall
5	Combined IP and EP	Combination of type 2 and 4

Table 2
Bladder Injury Severity Scale⁸

Grade ^a	Injury	Description
1	Hematoma	Contusion, intramural hematoma
	Laceration	Partial thickness
2	Laceration	Extraperitoneal (EP) <2 cm
3	Laceration	EP ≥2 cm or intraperitoneal (IP) <2 cm
4	Laceration	IP ≥2 cm
5	Laceration	EP or IP extending into bladder neck or ureteral orifice (trigone)

^aAdvance one grade for multiple injuries up to grade 3.

abdominal or suprapubic tenderness, shock, abdominal distension, inability to urinate, microscopic hematuria (5% of patients),⁶ and blood at the meatus. Guidelines for diagnostic imaging have been refined over recent years, and studies have identified patients at highest risk of injury in an attempt to reduce the number of unnecessary, time-consuming, and costly investigations.

An absolute indication for cystographic imaging is the presence of gross hematuria in conjunction with pelvic fracture. Relative indications for cystography are gross hematuria without pelvic fracture and microscopic hematuria with pelvic fracture (especially if $> 165 \times 10^6$ red blood cells [RBC]/L). Several series have shown that hematuria of $> 165 \times 10^6$ RBC/L identifies those at greatest risk

of bladder injury.² However, microscopic hematuria in general is a poor indicator of the presence of bladder rupture and cystography should not be routinely performed in patients who have microhematuria alone. Avey and colleagues noted that, in 687 patients with pelvic fracture and no bladder injury, only 196 (27.1%) of them had negative urinalysis results.² The presence of gross hematuria without pelvic fracture has been investigated by Fuhrman and colleagues, who prospectively showed that no bladder injuries were found in all 25 patients that were imaged.⁹ However, if 25% of IP ruptures occur without pelvic fracture, the use of cystography in these patients when clinical suspicion is high is appropriate.

Static cystography is quick and cost efficient. It should be performed only after concomitant urethral injury has been excluded. A scout radiograph of the abdomen is taken and 100 mL of 20% to 30% contrast material is injected through a urethral or suprapubic catheter to ensure gross extravasation is not present. Then, 200 to 250 mL of contrast material is administered and an abdominal film is obtained. It is vital that a scout, filled, and postdrainage radiograph are taken to visualize contrast that has extravasated behind the distended bladder; 10% of bladder injuries are diagnosed on the postdrainage radiograph.⁷ A computed tomography (CT) scan of the abdomen and pelvis has become a routine investigation in high-energy blunt trauma. As a result, CT cystograms are being performed more often with comparable results in some studies.¹⁰ Intravenous contrast and an excretory phase CT is not recommended for the assessment of traumatic bladder perforations as it does not guarantee a full bladder and therefore cannot rule out bladder perforation.¹ Cystography has a reported accuracy rate between 85% and

100%; however, proper technique and attention to detail are necessary to achieve high accuracy rates.⁵ Occasional false-negative results have been reported, mostly with penetrating trauma. As 24-hour, on-site radiologic support is not standard across Australia, all personnel involved in the management of trauma patients should be comfortable in performing and interpreting emergency cystourethrograms.

Treatment

Minor bladder injuries (American Association for the Surgery of Trauma [AAST] Grade 1) may be managed conservatively and even without a catheter in some cases. Indications for surgical exploration are (1) IP injury; (2) EP injury with bladder neck or ureteric orifice involvement; (3) bony fragments compressing or within the bladder; (4) all penetrating injuries; and (5) failed conservative management (eg, persistent contrast extravasation, excessive bleeding, or sepsis).

EP. Historically, all bladder ruptures were managed with operative primary repair. Currently, many EP injuries can be managed successfully with a conservative strategy.¹¹ Simple catheter drainage (urethral or suprapubic) followed by a cystogram after 10 days is successful in the majority of cases, with almost all ruptures healed by 3 weeks. Trauma victims who require emergency laparotomy for associated injuries may undergo primary repair of large or complex EP ruptures at the same time. With the push for early stabilization of the pelvis, patients are having open procedures within a few days of injury and, therefore, concurrent repair of bladder tears, which may have advantages in preventing subsequent pelvic infection. Surgical repair should be performed through cystotomy at the

dome of the bladder and a two- or three-layer closure from within is achieved with an absorbable running suture. The bladder neck and ureteric orifices should be closely inspected during exploration.

IP. IP ruptures can lead to sepsis and carry a higher mortality than EP injuries. They tend to be large, > 5 cm, and occur most commonly at the dome of the bladder. All of these injuries should be treated with prompt surgical exploration through a midline laparotomy incision and associated abdominal injuries should be excluded. Care should be taken to ensure minimal disturbance to pelvic hematoma. Extension of the laceration may be required to inspect the bladder neck and ureteric orifices. The laceration is closed using an absorbable running suture in a two- or three-layer closure. Any EP injuries should be closed at this point. A suprapubic catheter may be placed extraperitoneally through a separate stab incision. There is little evidence regarding the optimal time for catheter drainage with IP lacerations. Our practice is to perform a cystogram at 2 weeks when most IP ruptures have healed. Inaba and colleagues have suggested that simple dome lacerations may not need follow-up imaging at all.¹² Complex ruptures should have follow-up cystograms due to the nature of the injury; however, there is currently little evidence to support this course.

IP rupture is a manifestation of considerable blunt force and these patients often have devastating multisystem injuries. They may be immobile for extended periods, and removal of catheters and follow-up cystograms are often delayed as a result. The approach to these patients should be a shared consideration among all surgical teams involved

with the prioritization of injuries and their timely treatment.

Complications

Delayed diagnosis of bladder trauma can lead to severe consequences, which are largely related to urine leakage and include sepsis and peritonitis, abscess, urinoma, and potential reabsorption of electrolytes across the peritoneum. Urinary fistula (vesicovaginal, vesicocutaneous) can develop if persistent defects are not repaired. When treated appropriately, bladder trauma has an excellent prognosis.

Urethra

Blunt trauma accounts for almost all traumatic urethral injuries and the majority of these are associated with pelvic fracture. The incidence of male urethral injuries occurring with pelvic trauma ranges between 4% and 19% and up to 6% in women.¹ The male urethra is made up of the penile, bulbar, membranous, and prostatic urethra. It is divided into anterior urethra and posterior urethra by the urogenital diaphragm (UGD). The prostate is firmly attached to the posterior aspect of the pubis by the puboprostatic ligament and the membranous urethra is adherent to the external urinary sphincter and triangular ligament in the pelvic floor.

Mechanism

Anterior Urethral Injuries. This type of injury is seen most commonly in blunt trauma, but is not usually associated with pelvic fractures. It results from a strong blow to the perineum that causes the bulbar urethra to be crushed against the inferior border of the pubic symphysis. This typically occurs in a fall astride, a straddle injury from a vehicle accident, an assault, or from bicycle handlebars. Penile fractures, usually resulting

from intercourse, cause rupture of one or both corpora cavernosa, and in 20% of cases there is also injury to the anterior urethra.

Posterior Urethral Injuries. The mechanism of posterior urethral injuries has become an increasingly researched topic and is possibly much more complex than previously thought. Knowing the forces that hold the rigid pelvis in place and the traumatic forces that can disrupt its structure is crucial in understanding the mechanisms by which urethral injury occurs. The urethra is essentially tethered in two places: the prostate to the pubis by the puboprostatic ligament and distally by the sphincter and fascial layers of the UGD at the level of the membranous urethra. Posterior urethral rupture is believed to be caused by shearing forces. The membranous urethra is highly elastic and when external forces cause disruption of the pelvis these are translated to the soft tissues. The membranous urethra is stretched upwards as the tough perineal membrane anchors the bulbomembranous junction. Rupture occurs when the forces exceed the stretching capabilities of the urethra. Pelvic hematoma can contribute to this stretching and result in the cystographic appearance of *tear-drop bladder*.

Andrich and colleagues have recently suggested that pelvic fracture mechanisms play a much larger role in the mechanism of urethral injuries than previously thought.¹³ The researchers noted that many pelvic fractures occur without urethral disruption and, in fact, urethral injury is quite uncommon in pelvic trauma. They propose that the urethra is tethered at four points: bilaterally at both the puboprostatic ligament and the perineal membrane. Ligaments are stressed when fracture and displacement of bone occur, but these

ligaments can rupture before causing traction to the attached urethra. However, should the ligament stretch and traction force be applied to the urethra, rupture of the urethra can occur. This leads to the conclusion that rather than a shearing force, the injury is a result of avulsion, anterior tear (left and right forces pulling away and causing a midline vertical tear), crush, or direct laceration by a bony fragment.

Correlations between pelvic fracture type and urethral injury have been observed. The risk of urethral trauma increases with the number of

Urethroscopy may be useful in the detection of these injuries.

Classification

The treatment of a urethral injury relies on accurate diagnosis of a complete or partial tear (Figure 5). Partial injuries are more common in anterior urethral trauma, but current series on the incidence of complete or partial tears in posterior urethral injury are variable. This may be explained by the small numbers in some studies and the severity of injuries seen in some larger trauma centers. Webster and colleagues reviewed 19 reported

Correlations between pelvic fracture type and urethral injury have been observed. The risk of urethral trauma increases with the number of pubic rami fractured, involvement of the sacroiliac joint, and degree of inferomedial pubic rami displacement.

pubic rami fractured, involvement of the sacroiliac joint, and degree of inferomedial pubic rami displacement. In particular, straddle fractures combined with sacroiliac joint disruption have shown an odds ratio seven times higher than that of straddle or Malgaigne fractures alone.¹⁴ Aihara and colleagues showed that symphysis diastasis and inferior pubic rami fractures were independent predictors of urethral injury.¹⁵ Much of the literature is retrospective and numbers are small, but the correlation between anterior arch fractures and urethral injuries is seen in all studies.

Injuries of the Female Urethra. The female urethra consists of the posterior urethra only. It is rarely injured due to blunt trauma alone and is usually associated with pelvic fracture. Blood at the vaginal introitus is seen in more than 80% of women with urethral trauma and concomitant pelvic ring disruption.¹⁶ Retrograde urethrography is not used in the diagnosis of female urethral trauma.

series in 1983 and noted that complete ruptures were seen in 66% of patients.¹⁷ Complete ruptures are associated with contrast extravasation into the perineum when rupture of the distal perineal fascia or UGD occurs.¹³

Similar to bladder injuries, a number of classification systems have been developed to describe urethral injuries based on urethrographic appearance (Table 3,¹⁸ Table 4,⁸ Table 5¹). Although the actual grades may differ, they convey essentially the same information, differentiating between partial and complete disruptions in the anterior and/or posterior urethra.

Diagnosis

Blood at the meatus is seen in 37% to 93% of posterior urethral tears and in 75% of anterior urethral tears.^{19,20} Hematuria, the inability to pass urine, and dysuria may be present; however, the amount of hematuria correlates poorly to the severity of injury as complete rupture can mean minimal bleeding and small partial tears can

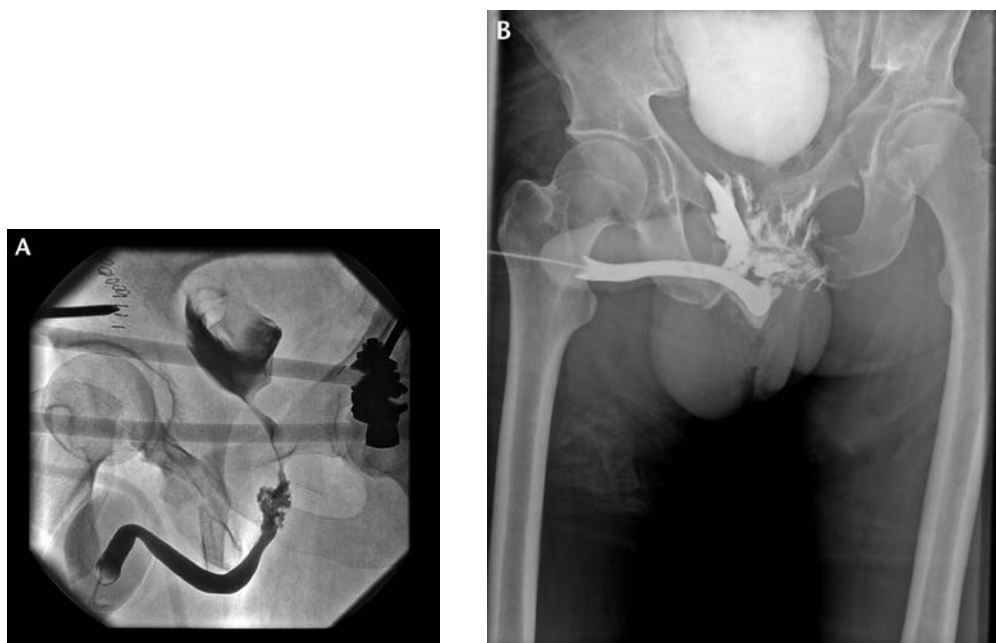


Figure 5. (A) Partial posterior urethral injury with contrast observed in bladder. (B) Complete urethral injury with starburst pattern of contrast extravasation seen on retrograde urethrogram. Bladder contrast present from previous imaging.

Table 3
Unified Anatomic Mechanical Classification of Urethral Injuries¹⁸

Type	Injury
1	Posterior urethra intact but stretched
2	Pure posterior urethral injury with tear of membranous urethra above the UGD; partial or complete
3	Combined anterior and posterior urethral injury with involvement of UGD; partial or complete
4	Bladder neck injury with extension into the urethra
4a	Injury of the base of the bladder with periurethral extravasation
5	Pure anterior urethral injury; partial or complete

UGD, urogenital diaphragm.

result in heavy bleeding. A high-riding prostate is an unreliable sign. Perineal ecchymosis and swelling are seen in urethral injuries as a direct result of trauma to the area or urinary extravasation and blood tracking within the limits of fascial planes (scrotum, perineum, abdominal wall). In anterior urethral injuries, the acknowledged “butterfly” pattern of

bruising is seen when Buck’s fascia is disrupted. The presence of pelvic trauma should alert clinicians to the possibility of injury.

The classic triad of blood at the meatus, inability to void, and a full bladder is uncommon and according to the Advanced Trauma and Life Support (ATLS) guidelines, radiographic evaluation should be

undertaken if any of the above exists.²¹ Examination of the rectum and/or vagina should be performed in all patients with suspected urethral injury related to pelvic fracture or penetrating trauma and can identify associated injuries. In the presence of blood at the meatus, a gentle attempt at catheterization has been shown to be acceptable and successful in up to 50% of patients.¹ It had been previously thought that insertion of a catheter into a torn urethra could result in conversion to a complete injury, disruption and infection of pelvic hematoma, and aggravated prostatic bed bleeding, although supporting evidence is lacking. Catheterization should be performed in situations where the patient is too unstable to have radiographic investigation. If urethral injury is suspected, a retrograde urethrogram should be performed whenever possible. If the expertise is available, visually guided catheter placement with a flexible cystoscope in the

Table 4
Urethral Injury Severity Scale⁸

Grade ^a	Injury	Description
1	Contusion	Blood at the urethral meatus; normal urethrography
2	Stretch injury	Elongation of urethra without extravasation of contrast
3	Partial disruption	Extravasation of contrast at injury site with contrast visualized in the bladder
4	Complete disruption	Extravasation of contrast at injury site without contrast visualized in the bladder; < 2 cm of urethral separation
5	Complete disruption	Complete transection with ≥ 2 cm of urethral separation or extension into prostate or vagina

^aAdvance one grade for bilateral injuries up to grade 3.

Table 5
European Association of Urology Classification of Blunt Anterior and Posterior Urethral Trauma¹

Grade	Injury	Description
1	Stretch injury	Elongation of the urethra without contrast extravasation
2	Contusion	Blood at the urethral meatus with no contrast extravasation
3	Partial disruption of anterior or posterior urethra	Contrast extravasation at the injury site with contrast visualized in proximal urethra or bladder
4	Complete disruption of anterior urethra	Contrast extravasation at injury site without visualization of contrast in proximal urethra or bladder
5	Complete disruption of posterior urethra	Contrast extravasation at injury site without visualization of contrast in bladder
6	Complete or partial disruption of posterior urethra	Associated tear to bladder neck or vagina

emergency department may lead to successful catheter placement, particularly in partial injuries.

Retrograde urethrography is the gold standard imaging technique in detecting injuries. It should occur before cystography and an initial scout radiograph should be taken first. A

small Foley catheter is inserted into the navicular fossa and either a penile clamp is applied or gentle insufflation of the balloon with 1 to 2 mL of saline; 20 to 30 mL of (60%) full-strength contrast material is injected while radiographs are taken in at least 2 planes (ideally, at a 30° oblique

angle). If done properly, the urethrogram allows classification of the injury and subsequent appropriate management.

Treatment

The aim of treatment in urethral trauma is to maintain continence and potency and to reduce the occurrence of strictures. Victims do not die of urethral trauma alone, but closely related pelvic ring disruption and multiple organ injury occur in 27% of patients.²² Primary treatment of these patients is in accordance with ATLS guidelines, where life-threatening injuries are assessed and managed first. Urinary diversion is the first step in the management of these injuries.

Partial Injuries. When treated appropriately, a partial rupture has a better outcome with lower morbidity than a complete rupture.²³ Anterior and posterior partial urethral tears can be treated with urinary diversion with a suprapubic or urethral catheter.^{24,25} Suprapubic catheters may be preferable in that they do not interfere with the urethral anatomy and allow micturating cystourethrography during follow-up. A gentle attempt at passing a Foley catheter per urethra or endoscopic railroading of a catheter can provide urethral catheterization. However, there should be as little manipulation of the urethra as possible. If difficulty is encountered, a suprapubic catheter should be placed and ultrasonography is helpful if the bladder is not easily palpable. The catheter should remain in place for 2 to 4 weeks until a micturating cystourethrogram is performed. If the patient voids satisfactorily and no contrast extravasation or stricture is seen, the catheter may be removed. In urethral catheterization, periurethral retrograde urethrography can be used to observe for contrast leakage.

Approximately 50% of partial tears treated with urethral catheterization will eventually require surgical management.²³ In anterior urethral blunt trauma, immediate or early repair is not recommended as the contused corpus spongiosum makes accurate debridement difficult. Penile fractures with anterior urethral rupture are usually partial in nature and may be primarily repaired at the same time as cavernosal repair.¹ Female urethral injuries are usually partial in nature and associated with concomitant bladder perforation or vaginal laceration. The urethra can be repaired primarily through the bladder in cases of joint bladder injury, or transvaginally if the tear is more distal.

Complete Injuries. Complete anterior urethral tears are generally treated with suprapubic catheterization and delayed urethroplasty. The management of complete posterior urethral injuries is more complex, with several treatment options and varying evidence to support them. The shift toward early stabilization of the fractured pelvis has meant increasing use of primary procedures. The treatment options are primary realignment, immediate primary repair, delayed primary repair and realignment, and delayed urethroplasty. The literature on this subject is large and studies tend to be retrospective, based on expert opinion, and have small sample sizes. Methods vary in the various options, but in the last decade several conclusions can be made.

Primary Realignment. Multiple methods of primary realignment have been described, making comparisons with other management techniques difficult. Currently, the most widely used technique is endoscopic realignment.²⁶⁻²⁸ Other

techniques described include interlocking magnetic sounds or catheters, open realignment with evacuation of pelvic hematoma, and the application of traction to the catheter or perineum. At our institution, we attempt to realign most urethral trauma with flexible endoscopy first. In patients with severe "pie in the sky" bladder trauma, open primary realignment is often performed, as most of these patients will have surgery for an associated injury. Endoscopic realignment is more favorable given it is performed under direct visualization and does not use suture repair bolsters or traction on the urethra that may cause tissue necrosis and further damage to the remaining sphincter mechanism. The proposed benefits of primary realignment are (1) reduction of the distraction defect of urethral ends; (2) prevention of stricture and, should it occur, urethrotomy or dilatation may be all that is required; and (3) alignment of the prostate and urethra should urethroplasty be required.

In 1996, Koraitim reviewed 42 years of literature and reported a stricture rate of 97% in patients treated with suprapubic catheterization alone, but concluded that stricture rates of primary realignment were less than previously thought (53%).¹⁴ However, there are concerns that primary realignment may increase the risk of incontinence, infection, bleeding, and impotence when compared with delayed urethroplasty.¹⁷ A review of the literature in 2009 by Djakovic and colleagues reported impotence rates of 35%, incontinence rates of 5%, and a stricture rate of 60%.¹ Some recent series have supported the use of primary realignment and possibly show lower impotence rates than suprapubic catheterization alone.^{26,28} The evidence on primary realignment must be interpreted

with caution as many series differ in their method of realignment. There is little distinction made between open and endoscopic realignment that likely differ in their potential to cause damage. Future series would ideally be prospective, aim to distinguish between different grades of impotence and the method of primary realignment, and reflect the full range of severity in posterior urethral trauma.

The use of primary realignment is highly dependent on the patient's stability and the extent of other injuries. Head injuries can restrict the number of procedures performed and limit the length of anesthesia given in theater. Often, diversion of urine in the safest, most effective manner is required; patients that are suitable for primary realignment should be selected carefully.

Immediate Primary Repair. Immediate primary repair is not recommended in most cases of complete urethral disruption. The extensive hemorrhage, ecchymosis, and swelling make division of planes and identification of anatomy and viable tissue extremely difficult. It has been associated with higher rates of incontinence (21%), impotence (56%), and stricture rates of 49%,²⁹ and has become widely discouraged. Immediate open realignment and repair should be used, however, in cases of associated rectal or bladder neck laceration.²⁵ Evacuation of pelvic hematoma may reduce tension on neurovascular bundles and the stretch effect on the urethra; however, there is a high risk of profuse bleeding and contamination in the acute period. Occasionally, on-table cystourethrography is performed to fully reassess the extent of lower urinary tract injuries when a patient has been transferred promptly to the operating room.

Delayed Primary Repair and Realignment. Realignment that occurs after a few days and up to 2 weeks from the time of injury is called delayed treatment. The theoretical benefit is that pelvic hematoma has settled, is unlikely to recur, and the patient is more stable.²⁰ Urinary diversion is achieved with a suprapubic catheter first and then reassessment and treatment with the surgeon's preferred technique can be implemented a few days later. There is little evidence supporting this protocol; the benefit is theoretical but satisfactory results have been seen in some female series. One prospective series on 17 men with complete ruptures of the urethra suggests that delayed primary realignment and repair—between 7 and 14 days—may also have acceptable outcomes.³⁰

Delayed Urethroplasty. Delayed urethroplasty is a widely accepted approach that is safe, effective, and allows planning and careful assessment of appropriate treatment modalities. Suprapubic catheterization is used for urinary diversion at the time of injury. Follow-up urethrography allows urologists to plan their approach and method of treatment as these injuries almost inevitably result in stricture. Formal urethroplasty is usually 3 to 6 months postinjury when all hematoma, tissue damage, and swelling have subsided. Many of these patients are immobile for extensive periods of time and having suprapubic catheter for 6 months is not problematic. The majority of complete posterior urethral ruptures result in short distraction defects. These can usually be overcome with single-stage perineal end-to-end anastomosis. Mobilization of the distal bulbar urethra to the base of the penis can provide 4 to 5 cm of length. The inherent elasticity of the urethra provides a

tension-free, spatulated, overlap anastomosis over defects between 2 and 2.5 cm.²²

In defects of up to 8 cm in length, the progression approach may be used.³¹ This method involves performing up to three maneuvers to allow a tension-free anastomosis: (1) midline division of the proximal corporal bodies; (2) inferior pubectomy; (3) rerouting of the bulbar urethra supracorporally. This approach may also be used in salvage repairs of failed anastomosis. Conditions preventing the success of delayed or salvage urethroplasty include: (1) defect >7 cm (may require interposition flap); (2) fistulae; (3) anterior urethral stricture causing reduced blood supply to bulbar urethra; (4) incontinence via external sphincter damage and/or bladder neck damage. Restricture rates after delayed anastomotic urethroplasty are less than 10% and the risk of impotence is 5%.¹ It is rare for a stricture to develop more than 6 months after a delayed urethroplasty.²⁰

Complications

Complications after blunt urethral trauma are common, but they may also be a result of associated traumatic injuries. Therefore, it is important to try to limit their occurrence.

Stricture. Strictures can have serious implications to a patient's quality of life. There is sometimes a need for multiple procedures and recognizing those cases at highest risk is valuable. Partial injuries heal well; in some cases normal urethral voiding without stricture may be seen.³² It has been shown in animal models that even when urethral ends are well opposed, mucosal healing does not occur and the defect is replaced with fibrous tissue instead.³³ When a distraction injury is left to heal and delayed urethroplasty is undertaken

at a later date, the urethral ends are not fibrotic. Fibrous tissue fills the gaps between the two ends, but the urethra is not in continuity. This may explain why anastomotic urethroplasty in these patients commonly heals without stricture. Strictures that are short and flimsy may be treated with optical urethrotomy or dilatation. Endoscopic procedures to achieve urethral continuity are appropriate in patients who have short strictures, mild distraction injuries, and a competent bladder neck. Previously described as an endoscopic urethrotomy-to-sound technique, with the advent of flexible endoscopy "cut to the light" procedures are being used increasingly. However, these patients have high rates of reoperation (80%).¹ Dense, longer strictures of the anterior urethra should not be repaired with anastomotic urethroplasty as chordee may form. These patients should undergo a substitution (either flap or graft) urethroplasty instead. Referral to an appropriately experienced urologist is vital in the management of these complex injuries.

Infection and Hematoma. Anterior urethral ruptures may leak urine and blood into penile or perineal tissues depending on the extent of disruption of fascial planes, which can lead to abscess formation and result in diverticulum, urethrocutaneous fistula, and necrotizing fascitis. Bladder neck injuries that are not repaired promptly can lead to incontinence and infection of pelvic metalware.

Impotence. Impotence in patients with concomitant urethral and pelvic trauma ranges in incidence from 20% to 60%. The cause may be vascular or neurogenic in origin, and there are differing opinions. Relatively good responses to intracavernosal injections suggest that the vascular

component is partly reversible.³⁴ The cavernosal nerves run in the retropubic space where they are susceptible to injury directly from the fractured anterior arch or manipulation during orthopedic or urological procedures. Sacral injuries and foraminal involvement can injure the S2-S4 roots, and the parasympathetic plexus surrounding the prostate is prone to injury from direct trauma or surgery. The internal pudendal artery may be damaged during pelvic ring disruption (ischial fracture) and in its course through the pelvic floor (where urethral rupture occurs). More locally, the penile neurovascular supply may be affected at any stage of urethral manipulation or formal urethroplasty.

Lower urinary tract trauma is a specialized injury that can have significant sequelae if left untreated. Recognizing and treating these injuries can be difficult in the multitrauma patient. In general, when the index of suspicion is high, retrograde imaging should be attempted whenever possible.

Impotence rates following pelvic trauma with urethral injury have been shown in one series to be as high as 42% and only 5% in those without urethral involvement.³⁵ This may be explained by the fact that impotence as a result of pelvic fractures usually occurs in those with more severe injuries and urethral injuries occur in those with more severe pelvic trauma. It is a long-term problem with complex factors involved, including those of a psychosocial nature. Impotence varies in each individual from complete impotence to being able to achieve erection without penetration. The recovery time for impotence post trauma is long and collateral circulation can sometimes be established in as much as 20% of patients up to 18 months later.²⁰

Incontinence. The intrinsic sphincter mechanism is often damaged during

the initial injury and continence after trauma is often reliant on a competent bladder neck, although recently some authors suggest otherwise.³⁶ Radiologic evidence of an open bladder neck should not be considered definite and if there is suspicion, endoscopic visualization on immediate entry into the bladder from a suprapubic tract can be useful.^{20,36}

Conclusions

Lower urinary tract trauma is a specialized injury that can have significant sequelae if left untreated. Recognizing and treating these injuries can be difficult in the multitrauma patient. In general, when the index of suspicion is high, retrograde imaging

should be attempted whenever possible. Expert urological opinion should be sought early and the safest method of urinary diversion within the experience of the clinician should be attempted. The aim of bladder and urethral trauma management should be to maintain continence, potency, and the avoidance of stricture. ■

Data were provided by The Victorian State Trauma Outcomes Registry (VSTORM), a Department of Human Services-sponsored project.

References

- Djakovic N, Plas E, Martinez-Piñero L, et al. *Guidelines on Urological Trauma*. Arnhem, the Netherlands: European Association of Urology; March 2009. http://www.uroweb.org/gls/pdf/20_Urological_Trauma%202009.pdf. Accessed August 3, 2011.
- Avey G, Blackmore CC, Wessells H, et al. Radiographic and clinical predictors of bladder rupture in blunt trauma patients with pelvic fracture. *Acad Radiol*. 2006;13:573-579.
- Carroll PR, McAninch JW. Major bladder trauma: mechanisms of injury and a unified method of diagnosis and repair. *J Urol*. 1984; 132:254-257.
- Flanchbaum L, Morgan AS, Fleisher M, Cox EF. Blunt bladder trauma: manifestation of severe injury. *Urology*. 1988;31:220-222.
- Sandler CM, Goldman SM, Kawashima A. Lower urinary tract trauma. *World J Urol*. 1998; 16:69-75.
- Bodner DR, Selzman AA, Spirnak JP. Evaluation and treatment of bladder rupture. *Semin Urol*. 1995;13:62-65.
- Sandler CM, Hall JT, Rodriguez MB, Corriere JN Jr. Bladder injury in blunt pelvic trauma. *Radiology*. 1986;158:633-638.
- Moore EE, Cogbill TH, Jurkovich GJ, et al. Organ injury scaling. III: chest wall, abdominal vascular, ureter, bladder, and urethra. *J Trauma*. 1992;33:337-339.
- Fuhrman GM, Simmons GT, Davidson BS, Buerk CA. The single indication for cystography in blunt trauma. *Am Surg*. 1993;59:335-337.
- Vaccaro JP, Brody JM. CT cystography in the evaluation of major bladder trauma. *Radiographics*. 2000;20:1373-1381.
- Corriere JN Jr, Sandler CM. Management of the ruptured bladder: seven years of experience with 111 cases. *J Trauma*. 1986;26:830-833.
- Inaba K, McKenney M, Munera F, et al. Cystogram follow-up in the management of traumatic bladder disruption. *J Trauma*. 2006; 60:23-28.
- Andrich DE, Day AC, Mundy AR. Proposed mechanisms of lower urinary tract injury in fractures of the pelvic ring. *BJU Int*. 2007;100: 567-573.
- Koraitim MM. Pelvic fracture urethral injuries: evaluation of various methods of management. *J Urol*. 1996;156:1288-1291.
- Aihara R, Blansfield JS, Millham FH, et al. Fracture locations influence the likelihood of rectal and lower urinary tract injuries in patients sustaining pelvic fractures. *J Trauma*. 2002;52:205-208; discussion 208-209.
- Perry MO, Husmann DA. Urethral injuries in female subjects following pelvic fractures. *J Urol*. 1992;147:139-143.
- Webster GD, Mathes GL, Selli C. Prostatomembranous urethral injuries: a review of the literature and a rational approach to their management. *J Urol*. 1983;130:898-902.
- Goldman SM, Sandler CM, Corriere JN Jr, McGuire EJ. Blunt urethral trauma: a unified, anatomical mechanical classification. *J Urol*. 1997;157:85-89.
- McAninch JW. Traumatic injuries to the urethra. *J Trauma*. 1981;21:291-297.
- Mundy AR. Pelvic fracture injuries of the posterior urethra. *World J Urol*. 1999;17:90-95.
- American College of Surgeons. *Advanced Trauma Life Support Student Course Manual*, 8th ed. Chicago: American College of Surgeons; 2008.
- Chapple CR, Png D. Contemporary management of urethral trauma and the post-traumatic stricture. *Curr Opin Urol*. 1999;9:253-260.
- Cass AS, Godec CJ. Urethral injury due to external trauma. *Urology*. 1978;11:607-611.

24. Jackson DH, Williams JL. Urethral injury: a retrospective study. *Br J Urol.* 1974;46: 665-676.
25. Koraitim MM. Pelvic fracture urethral injuries: the unresolved controversy. *J Urol.* 1999;161: 1433-1441.
26. Elliott DS, Barrett DM. Long-term followup and evaluation of primary realignment of posterior urethral disruptions. *J Urol.* 1997;157: 814-816.
27. Gheiler EL, Frontera JR. Immediate primary realignment of prostatomembranous urethral disruptions using endourologic techniques. *Urology.* 1997;49:596-599.
28. Mouraviev VB, Coburn M, Santucci RA. The treatment of posterior urethral disruption associated with pelvic fractures: comparative experience of early realignment versus delayed urethroplasty. *J Urol.* 2005;173: 873-876.
29. Koraitim MM, Marzouk ME, Atta MA, Orabi SS. Risk factors and mechanism of urethral injury in pelvic fractures. *Br J Urol.* 1996; 77:876-880.
30. Mundy AR. The role of delayed primary repair in the acute management of pelvic fracture injuries of the urethra. *Br J Urol.* 1991;68: 273-276.
31. Webster GD, Ramon J. Repair of pelvic fracture posterior urethral defects using an elaborated perineal approach: experience with 74 cases. *J Urol.* 1991;145:744-748.
32. Turner-Warwick R. Prevention of complications resulting from pelvic fracture urethral injuries—and from their surgical management. *Urol Clin North Am.* 1989;16:335-358.
33. Gibson GR. Urological management and complications of fractured pelvis and ruptured urethra. *J Urol.* 1974;111:353-355.
34. Mark SD, Keane TE, Vandemark RM, Webster GD. Impotence following pelvic fracture urethral injury: incidence, aetiology and management. *Br J Urol.* 1995;75:62-64.
35. King J. Impotence after fractures of the pelvis. *J Bone Joint Surg Am.* 1975;57:1107-1109.
36. Andrich DE, Mundy AR. The nature of urethral injury in cases of pelvic fracture urethral trauma. *J Urol.* 2001;165:1492-1495.

Main Points

- Associated injuries in bladder trauma are common and include pelvic fractures (93%-97%), long bone injuries (50%-53%), and central nervous system (28%-31%) and thoracic injuries (28%-31%).
- Several mechanisms of bladder damage associated with pelvic fracture have been described: (1) bony fragments lacerating the extraperitoneal (EP) surface; (2) avulsion due to severe displacement forces when the rigid pelvis is fractured and ligamentous attachments are disrupted; and (3) direct force causing a "burst" injury to a full bladder that classically causes a large horizontal laceration at the dome.
- Bladder trauma can be broadly classified as contusions of the bladder wall or intramural hematomas that are self-limiting and require no specific treatment, EP injuries that occur in 60% of all bladder traumas, intraperitoneal (IP) lacerations that can be seen approximately 25% of the time in patients without pelvic fracture, and combined IP and EP perforations that occur in 2% to 20% of all injuries. Bladder contusion is probably the most common type and is a relatively minor injury that does not require specific treatment.
- Gross hematuria is the most common sign associated with bladder rupture. It has been reported in 100% of all bladder injuries and its presence in conjunction with pelvic trauma is a well-documented predictor of injury. Other signs and symptoms include abdominal or suprapubic tenderness, shock, abdominal distension, inability to urinate, microscopic hematuria (5% of patients), and blood at the meatus.
- Minor bladder injuries (American Association for the Surgery of Trauma Grade 1) may be managed conservatively and even without a catheter in some cases. Indications for surgical exploration are (1) IP injury; (2) EP injury with bladder neck or ureteric orifice involvement; (3) bony fragments compressing or within the bladder; (4) all penetrating injuries; and (5) failed conservative management (eg, persistent contrast extravasation, excessive bleeding, or sepsis).
- Blunt trauma accounts for almost all traumatic urethral injuries and the majority of these are associated with pelvic fracture. The incidence of male urethral injuries occurring with pelvic trauma ranges between 4% and 19% and up to 6% in women.
- The treatment of a urethral injury relies on accurate diagnosis of a complete or partial tear. Partial injuries are more common in anterior urethral trauma, but current series on the incidence of complete or partial tears in posterior urethral injury are variable. Similar to bladder injuries, a number of classification systems have been developed to describe urethral injuries based on urethrographic appearance. Although the actual grades may differ, they convey essentially the same information, differentiating between partial and complete disruptions in the anterior and/or posterior urethra.
- Retrograde urethrography is the gold standard imaging technique in detecting injuries.
- The aim of treatment in urethral trauma is to maintain continence and potency and to reduce the occurrence of strictures. Victims do not die of urethral trauma alone, but closely related pelvic ring disruption and multiple organ injury occurs in 27% of patients.
- Complications after blunt urethral trauma are common, and include stricture, infection, hematoma, impotence, and incontinence.